

The quantum mind of Stuart Hameroff

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Today we're talking with Stuart Hameroff, Professor Emeritus at the Departments of Anesthesiology and Psychology, and Director of the Center for Consciousness Studies, at the University of Arizona. Dr Hameroff is best-known for his research on 'quantum consciousness', an alternative model to the accepted view of how consciousness arises. With Sir Roger Penrose, Dr Hameroff has proposed that consciousness arises at the quantum level within structures inside neurons, known as microtubules.

Many TDG readers have mentioned their interest in this research, but have also stated that they do have some trouble grasping the concepts involved. As such, we recently had a short chat with Dr Hameroff to clarify some of these issues, and also to ask other questions related to the idea of 'quantum consciousness'.

GT: Greetings Stuart, and thanks for taking the time to talk with us. First off, can I start by asking you to describe, as best possible in 'everyday' terms, the current paradigm's view of consciousness, and how your 'quantum consciousness' hypothesis differs from it. Also, what are 'microtubules'.

SH: The prevalent paradigm is that brain neurons (nerve cells) and synapses (connections between nerve cells) act like bits and switches in computers, that consciousness is essentially computation, essentially no different (except in degree of complexity) from what is happening in your laptop. Microtubules are the structural components inside neurons, part of the cell cytoskeleton. But in addition to being bony girders, they seem to also process information - the nervous system within each cell.

The Penrose-Hameroff quantum consciousness hypothesis proposes that quantum computations in microtubules inside the brain's neurons convert pre/subconscious possibilities (manifest as dream-like quantum information) to particular information (choices, perceptions) by a type of quantum state reduction, or collapse of the wave function. The reduction itself - an instantaneous event connected to the fundamental level of reality, as suggested by Penrose - is a conscious moment. A sequence of such moments gives our stream of consciousness.

Quantum computation differs fundamentally from classical computation, utilizing quantum superpositions of information bits (quantum bits, or qubits, e.g. both 1 AND 0) which communicate/interact by nonlocal entanglement, another strange quantum behavior.

The mechanism of reduction (conversion from quantum to classical) which produces the solution to a quantum computation is a big question - the so-called collapse of the wave function. In technological quantum computers an external measurement will cause reduction. In an isolated system (e.g. the brain) the Penrose suggestion of self-collapse due to an objective threshold (objective reduction) is based on the idea that superpositions are separations/curvatures in

underlying spacetime geometry, that these separations are unstable and will reduce to one particular curvature/separation after a specific time t . The larger the separation/superposition, the faster it will self-collapse (and the more intense the experience)

GT: Is the concept of 'qualia' one which provides a fundamental challenge to the physicalist worldview? Is it time that we considered 'information' as something as 'real' as the physical world?

SH: I would say qualia are a challenge for physicalism, but physicalists tend to trivialize the nature of qualia. Australian philosopher Frank Jackson's famous 'knowledge argument' about Mary (the colorblind vision neuroscientist who knows everything about color vision but lacks the actual experience) frames the question well/ I disagree with the the physicalist answer which states that when Mary DOES gain color vision and appreciates qualia she has merely gained new information, or knowledge. I don't equate qualia with information; I think that approach is a bait and switch. Interestingly, quantum information is not really information (its a misnomer actual signaling cannot occur). Quantum information may confer qualia.

Some say the universe is made of information. David Chalmers' "dual aspect theory" says that such information has both a physical aspect and an experiential (qualia) aspect. This is similar to what William James had said, and Bertrand Russell's neutral monism, in which an underlying entity gives rise to both physical and mental qualities.

GT: In your opinion, does the hypothesis of 'quantum consciousness' provide a model for anomalous experiences such as Out of Body Experiences (OBEs) and Near Death Experiences (NDEs)?

SH: I would say possibly yes. Under normal circumstances consciousness occurs in the fundamental level of spacetime geometry confined in the brain. But when the metabolism driving quantum coherence (in microtubules) is lost, the quantum information leaks out to the spacetime geometry in the universe at large. Being holographic and entangled it doesn't dissipate. Hence consciousness (or dream-like subconsciousness) can persist.

GT: In your review of Christof Koch's book *The Quest for Consciousness*, you say "Consciousness occurs in dendrites, and the results are conveyed elsewhere by axonal spikes. What exactly are you referring to as 'consciousness' at the dendrite level? I have this view of consciousness as being the sum creation of many individual actions/reactions at the microscopic level. So are you referring to discrete conscious experiences (e.g. dendritic reaction to sensory input), or to some other 'action' which amounts to consciousness? Apologies for the confusing question.

SH: The conventional view is that the neural correlate of consciousness is in networks of neurons connected by chemical synapses - axons to dendrites - which are serial, though you can have parallel lines of serial connections. Axonal depolarizations, or spikes, are relatively easy to record, and are robust. Therefore the view is that spikes are the currency of consciousness. However the vast majority of actual processing occurs in dendrites (numerous dendrites per neuron). Electrophysiological correlates of consciousness (e.g. gamma EEG, coherent 40 Hz) are

produced by dendrites, and dendrites are interconnected by gap junctions (forming what I call hyper-neurons) which actually DO account for gamma EEG/40 Hz. John Eccles and Karl Pribram have said that consciousness occurs in dendrites. I agree, though I think dendritic webs, or hyper-neurons are the actual site. A hyper-neuron may include tens or hundreds of thousands of gap junction-connected neurons. The quantum state may extend through the gap junctions so that quantum computations in the collection of microtubules within the many dendrites of a single hyper-neuron at a particular time mediate consciousness.

GT: How did you arrive at this idea of quantum consciousness in microtubules? Were you actively searching for an 'outside the paradigm' idea, or did you happen upon it by accident?

SH: I was studying cell division in normal and cancer cells 30 years ago. I got intrigued by how the chromosomes were precisely separated by mitotic spindles - microtubules. I thought the microtubules must be processing information to account for the spatial precision. Then it was discovered that neurons were full of microtubules, so I assumed consciousness must extend downward into neuronal interiors to include microtubules.

But another layer of information processing was just more computation. Someone asked - "Say you are right. How would that explain qualia?" They were right. I couldn't. Then I read Roger Penrose's *The Emperor's New Mind* (Amazon [US](#) and [UK](#)), suggesting there must be quantum mechanisms at work in consciousness, specifically objective reduction. But he lacked a structure for his quantum computing by objective reduction in the brain. I thought microtubules might be the structure he needed for his quantum computing, and his objective reduction the mechanism I needed for microtubules. We hooked up and published our model in 1994/95. We've been attacked ever since but are still kicking, generating testable predictions which thus far have held true.

GT: Well, focusing on that for a second: as a scientist who works 'outside' the paradigm, do you encounter much 'unfair' resistance to your work? That is, some form of persecution (entirely separate to spirited and intelligent debate)?

SH: Persecution is a bit harsh, but yes, the conventional wisdom proponents are more interested in protecting their turf than honestly considering alternatives. But it's much better to be criticized than ignored. On the other hand skepticism is good (there are a lot of whacky ideas floating around - I just think ours is not one of them). But the skeptics should be as skeptical of the conventional dogma which is extremely weak. The title of Roger's book *The Emperor's New Mind*, aimed at artificial intelligence (or maybe specifically at Marvin Minsky), was the perfect example. Roger called their bluff. AI is naked, haughty and pretentious when it comes to the question of consciousness.

GT: You (or your theory) recently came in for some criticism from *Scientific American's* resident skeptic, Michael Shermer. In your reply to Shermer you said "Pre-conscious (unconscious/subconscious) information exists as quantum superpositions - multiple coexisting possible actions or experiences - which, upon reaching a specified threshold at the moment of consciousness/self-collapse, choose a particular action or experience." This seems to border on the mystical, with reality basically being created by particular actions and choices. Do you feel

that your research sometimes bridges a gap between science and religion (or perhaps more correctly, the 'numinous')?

SH: I'm not an idealist, like Bishop Berkeley or Hindu approaches, in which consciousness is all there is. Nor am I a Copenhagenist in which consciousness causes collapse (and chooses reality from a number of possibilities). But somewhere in between. Consciousness exists on the edge between the quantum and classical worlds.

I think more like a quantum Buddhist, in that there is a universal proto-conscious mind which we access, and can influence us. But it actually exists at the fundamental level of the universe, at the Planck scale.

GT: Seeing we're heading for the religion end of things, what about the debate over the 'consciousness' of other organisms (e.g. paramecium, plants, fungi, dogs, dolphins etc). Is there some fundamental difference in cellular structure, or the microtubules, which might separate humans from all other organisms (at least in terms of a mechanism for conscious experience)? Or are we all capable?

SH: Only in the brain are microtubules arranged so that a large number (e.g. in hyper-neurons) will be isolated in superposition to reach threshold in a reasonably short time. A paramecium might have a moment of consciousness every hour or so (though it would be difficult to maintain isolation for so long); we have 40 conscious moments per second.

GT: You talk about the action of anesthetics in selectively erasing consciousness. Do hallucinogenic substances also act at a similar level (though not necessarily erasing consciousness)?

SH: Consciousness exists on the boundary between the quantum subconscious and the classical world. I think hallucinogens promote the quantum state in their receptors (there is evidence to support that) and other proteins including microtubules. I think psychedelic altered states (and dreams) are like consciousness except the boundary is pushed more into the quantum phase - multiple coexisting possibilities, deep interconnections, distorted reality, sheaf logic, timelessness....and (for psychedelics) more conscious events per classical clock time, and more intense experience.

GT: Thanks for your time in talking to us Stuart, and appreciate your candid - and fascinating - answers. Hope to talk with you again soon.